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Danube Transnational Programme

GRENDEL

Green and efficient Danube fleet

"Towards modernisation & greening of Danube inland waterborne sector and strengthening its competitiveness"

Output 4.1 – Innovative & greening inland vessel concepts of FLUVIUS

Work Package 4 Preparatory actions

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Contributing Authors

Name	Organisation	Email
Zoltán Haász	External expert – FLUVIUS	haasz.zoltan@t-online.hu
András Kiss	FLUVIUS	akiss@plimsoll.hu
László Dudás	FLUVIUS	l.dudas@fluvius.hu

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Abbreviations

Abbreviation	Explanation
EU	European Union
FNPV	Financial net present value
FRR	Internal rate of return
GBER	General Block Exemption Regulation
IWT	Inland Waterway Transport
MS	Motor Ship (interchangeable with MV – Motor Vessel)
SME	Small and Medium Enterprises
VAT	Value Added Tax

1 Executive Summary

1.1 Individual vessel concepts

To maintain its market position and reputation as an efficient, safe, and environmentally friendly mode of transport, inland waterway transport must adapt to new technological developments, market requirements, and improve its environmental performance and efficiency.

The main goal of the WP4 work package of the GRENDEL project is to assist fleet operators in the specific preparatory activities for investing in the green fleet. The companies involved should be treated as "forerunners" as these areas do not really have previous experience so they can even provide good practices for others to follow in the future.

FLUVIUS Shipping and Forwarding Ltd. has examined some possibilities for "green investments" over the next 2-3 years. Their fleet sail on the Upper, Middle and Lower Danube, thus providing a good "showcase" for marketing in order to spread "green shipping". In the context of the fleet investment planning phase of the project package, the concepts around which FLUVIUS has selected during the cost-benefit analysis have already been developed. For example, some concepts were developed for several vessels, and then further analysed for licensing, design, and installation costs only for a certain ship.

Five concepts were finally selected and analysed, including:

- **Solar panel installation** including hatch cover conversion (in relation to MS Melanie-H),
- Installation of a **hybrid propulsion engine** and other equipment and rearrangement of the engine compartment (in relation to MS Johanna),
- **Hull conversion** concept (in relation to MS Ulm),
- **Main engine replacement** investment (in relation to MS Elsava),
- **Renovation of electrical network** (in relation to MS Johanna).

Following a comprehensive fleet survey, detailed development concepts were developed with the involvement of external experts. The analysed development concepts undoubtedly contribute to the objectives of the GRENDEL project.

1.2 Financial aspects of the vessel concepts

In the financial cost-benefit analysis, we use the following general assumptions, which basically determine the methodology of the analysis:

In the case of the concepts, we defined small and large investment cases, which were calculated with the difference between investment and operational costs when calculating the aid intensity and the financial return. None of the concepts include ineligible costs.

Based on the examination of the development proposals from the point of view of state support, it can be said that two types of support items could be considered. The named GBER grant items are as follows:

- Environmental aid - Article 36 - Investment aid enabling undertakings to go beyond EU environmental standards or to increase the level of environmental protection in the absence of EU standards
- Environmental aid - Article 38 - Investment aid for energy efficiency measures

When classifying the elements of development, we took Chapter 3 of the 2nd version of the study entitled *"Model State Aid scheme & public support measures"* prepared in the GRENDEL project, dated *24.04.2020.*

In the light of this (and the fact that FLUVIUS Ltd. is a small enterprise), the maximum aid intensity that can be applied for is 50% and 60% for each concept.

The start of the project implementation (investment) is 2022, the activation year of the installed devices is 2023. The reference period of the study is 15 years. When calculating costs and revenues, we used a discount rate of 4%.

We found in the financial analysis that the concepts can only be implemented with the help of state subsidies, which will be repaid in a different period later. The level of these subsidies differs from concept to concept. The table below summarizes the aid intensity by concept.

Name of concept	Aid intensity
Hatch cover renovation and solar panel installation (MS Melanie-H)	59%
Motors for hybrid propulsion, related costs (MS Johanna)	27%
Hull conversion costs (MS Ulm)	31%
Main engine replacement costs (MS Elsava)	48%
Electricity network renovation costs (MS Johanna)	58%

1. Table: Aid intensity by concept

1.3 Environmental aspects of the development concepts

In the present study, the general examination and analysis of the special environmental legal regulations arising in connection with the conversion of 4 selected vessels of the FLUVIUS fleet. Regarding river vessels, environmentally harmful emissions occur mainly in the areas of air quality protection, waste management and wastewater treatment.

Each of the elaborated vessel concepts is a development related to propulsion, ship performance, ship consumption reduction and improvement of the ship's sailing characteristics, which must also comply with the applicable European Union and domestic legal regulations. With the redesigns and improvements, there will be a change mainly in air emissions with decreasing pollutants for ships.

As expected, the reduction of harmful air pollutant emissions can be predicted by replacing more modern engines, using renewable energy, inserting solar panels, introducing hybrid propulsion, and installing catalysts. This will make a company's eco-friendly river shipping even more attractive in an increasingly global competitive environment. Indeed, one of the important indicators of the delivery of goods is now the ratio of CO2 emissions to the weight of the goods and the kilometres travelled in freight transport. To this end, the present developments will result in much better supply positions for converted vessels in terms of environmental aspects.

1.4 Lessons learned

Finally, we collected the lessons learned during the preparation and elaboration of the vessel concepts. The main learnings are as follows:

- Such a complex, comprehensive environmental survey has not been carried out for the fleet before: air loads (emissions), water pollution, wastewater generation, noise and vibration protection, waste management, energy management, material flow, hazardous material use, total emissions - ecological footprint.
- It has been revealed that old engines emission values are not dramatically different from the Stage5 engine – NO_x are higher.
- In 2020 stage5 engines does not exist by their own, therefore exhaust gas treating equipment must be added.
- The price of the exhaust treater system is almost the same (90%) as the price of the main engine.
- The analysis revealed that the conversion of the hull was specifically costly, with its return uncertain.
- It has been proven that the installation of a phase corrector is mandatory on all ships to promote greener operation.
- Installation of solar panels is feasible, technically possible, so we would implement it on our vessels.

2 Introduction

2.1 About FLUVIUS

FLUVIUS Shipping and Forwarding Ltd. is a Hungarian small-sized company, established in 2001. The company's main profile is shipping, including inland navigation. In 2018, we transported nearly 168,300 tons of goods on the Danube-Main-Rhine waterway axis.

The most common actions which FLUVIUS take is buying used vessels. FLUVIUS keep vessels in own fleet for quite long, one of our vessels has been owned by the company for 19 years.

FLUVIUS fleet consists of 6 vessels, from which 4 was involved in the elaboration of the vessel concepts, namely MS Elsava, MS Johanna, MS Melanie-H and MS Ulm.

2.2 History of the vessel concepts

In the frame of GRENDEL project, FLUVIUS aimed to examine different solutions to reduce the greenhouse gas emission and the ecological footprint of their fleet.

First, a comprehensive assessment of 4 vessels were conducted, in different fields. The electrical system was reviewed, and the emission of the vessels were measured as a first step. The experts made a thorough calculation regarding the electricity consumption and examined where it is possible to place solar panels on board. Also, they observed the consumption habits of the vessels. Some protentional development concepts were selected, on which the experts made an evaluation from different aspects.

Finally, five development concepts were selected, which were also analysed from an environmental and financial point of view.

2.3 Methodology of financial analysis

2.3.1 Applied methodology and assumptions

The methodology of the financial analysis is basically determined by the grant category of the project promoter according to the EU grant rules, the title of the grant and the amount and extent of the grant, taking into account both the eligible and ineligible costs of the investment. For each activity and cost item, we examine the eligibility and title of the grant.

In the application construction, the supported activities can be basically divided into two groups:

- public purpose, income generating,
- public, non-income generating.

Although the examined project does not result in an increase in turnover at FLUVIUS Shipping and Forwarding Ltd. (hereinafter FLUVIUS Ltd.), it means significant cost savings and revenue growth in the case of some concepts. As a result, we found that the project could be classified as a public, revenue-generating category. The analysis was performed accordingly below.

In the financial cost-benefit analysis, we use the following general assumptions, which fundamentally determine the methodology of the analysis.

Development difference or historical cost method

In the analysis, we use the developmental difference, also known as the incremental method. According to this, financial analysis builds on changes that occur as a result of development. We determine the expected cash flows (small investment) for the planned project in the case of a less

environmentally friendly investment, and the expected revenues and expenditures for the implementation of the project. The difference between the cash flows of the project realization and the small investment project status provides the basis for the analysis.

Real value planning

The analysis was performed at constant prices, i.e. at the price level of 2020.

Examined time interval

The time interval examined in the financial analysis, in which cash flows and other effects, we ultimately examine the return on the project. The examined period is 15 years, which does not include the investment period.

Determination of the financial discount rate

Since we also calculate real prices in the financial analysis, a real discount rate should be used when determining the net present value of the project. For real price planning, according to Commission Delegated Regulation (EU) No 480/2014 of 3 March 2014 (17), the proposed financial discount rate is 4%, so this value has been used.

VAT

FLUVIUS Ltd. is subject to VAT, so VAT is not included in the cost-benefit analysis.

Price level applied

In the calculations, we use the 2020 price level.

Beneficiary and maintainer of the project

The beneficiary and maintainer of the project is FLUVIUS Ltd. In the financial analysis, the data are given in EUR for the whole period. The starting year of the analysis is 2020.

Applicable development aid entitlements

Based on the examination of the development proposal from the point of view of state aid, it can be said that two types of aid claims arise. The named GBER grant items are as follows:

- Environmental aid - Article 36 - Investment aid enabling undertakings to go beyond EU environmental standards or to increase the level of environmental protection in the absence of EU standards
- Environmental aid - Article 38 - Investment aid for energy efficiency measures

When classifying the elements of the development, we took Chapter 3 of the 2nd version of the study entitled *"Model State Aid scheme & public support measures"* prepared in the GRENDEL project, dated *24.04.2020.*

The tables presented in the document when introducing the financial analysis of the vessel concepts, are only parts of the overall analysis which was made regarding each concept.

In the case of proposals containing individual concepts or their implementation, when accurate data are available instead of estimates, it is proposed to revise the financial analysis. The present cost-benefit analysis study is an ex ante study, so the data for the future are based on estimates based on the past experiences and data of FLUVIUS Ltd. and their experts.

3 Vessel concepts

3.1 Solar panel installation on vessels – including hatch cover renovation

The first concept of the project concerns the MS Melanie-H from FLUVIUS fleet. In accordance with the concept, we examined the installation of solar panels on the ship and the system serving it, supplemented by the renovation of the electrical network and hatch covers, in the absence of which the project is not feasible. In the financial analysis, the comparison was based on an investment involving the minor refurbishment of hatch covers and their covering with UV-resistant tarpaulins.

3.1.1 History

Prior to the development of the concept, the experts conducted a full survey on four vessels. The electrical system of the vessel was assessed, their power and consumption were measured, and the possibilities of placing solar panels on board were examined.

The electrical power consumption of vessels varies, depending greatly on the load, the weight of the cargo, the direction of traffic (uphill, downhill or waiting / unloading), the nature of the river and the nature and number consumers which are not necessary for the operation of the vessel. There are many inductive (electric motor) consumers on ships, with low efficiency, so depending on their use, the rate of reactive power is very high. Environmental emissions from high levels of reactive power can be reduced by using renewable energy sources and phase correctors.

It can be said that the electricity produced by solar power plants is much cheaper than that produced by diesel power generators. The payback period before developments is 2.2 years, while after investments it changes to 2.7 years. Considering that the planned average age of a solar power plant is 25-30 years this is a very good payback period. Age does not mean that the solar power plant will have to be replaced over time, but Tier1-rated manufacturers offer a 25-year performance guarantee, meaning they guarantee that the electrical performance of the solar module will not fall below 80% during this time.

1. Figure: MS Melanie-H

3.1.2 Cost-benefit analysis

Investment costs

The investment costs are presented separately for the two cases.

Investment costs	Gross price	Net price	VAT
Solar panel, inverter, optimizer	16 319,50 €	12 850,00 €	3 469,50 €
Construction of support structure, solar and AC cable route	5 961,94 €	4 694,44 €	1 267,50 €
Fee for the construction of a basic system	3 880,56 €	3 055,56 €	825,00 €
Battery pack approx. 13KW for storing electricity	14 993,06 €	11 805,56 €	3 187,50 €
Other system components for switching (EDU, metering system)	1 234,72 €	972,22 €	262,50 €
Necessary system components to receive the solar system	1 763,89 €	1 388,89 €	375,00 €
Main distributor replacement	81 138,89 €	63 888,89 €	17 250,00 €
Hatch cover renovation	127 000,00 €	100 000,00 €	27 000,00 €
Total assets and construction	**252 292,56 €**	**198 655,56 €**	**53 637,00 €**
Design costs	1 763,89 €	1 388,89 €	375,00 €
Licensing costs	352,78 €	277,78 €	75,00 €
Total services	**2 116,67 €**	**1 666,67 €**	**450,00 €**
Total investment costs	**254 409,22 €**	**200 322,22 €**	**54 087,00 €**

2. Table: Investment costs for large investments (Concept1)

Investment costs	Gross price	Net price	VAT
Hatch cover repair + installation of UV resistant tarpaulins	3 810,00 €	3 000,00 €	810,00 €
Total assets and construction	**3 810,00 €**	**3 000,00 €**	**810,00 €**
Licensing cost	- €	- €	- €

Investment costs	Gross price	Net price	VAT
Design costs	- €	- €	- €
Total services	**- €**	**- €**	**- €**
Total investment cost	**3 810,00 €**	**3 000,00 €**	**810,00 €**

3. Table: Investment costs for small investments (Concept1)

In both cases, all cost items are eligible, so there is no investment element or service of which value should not be considered in subsequent calculations. Investment costs would be incurred in 2022.

The cost of assets and services has been determined based on quotations or previous experience. Reconstruction costs were estimated based on the costs of previous reconstruction and relocation work. In the case of licensing, we estimated the costs based on official fees, and in the case of design, we relied on the estimation of the design team that compiled the technical content.

We plan to implement the project in 2022. We plan to activate the investment by 2023.

Operational costs

Operating costs are presented according to the development difference (incremental) method for both the small investment and the large investment versions, and then we continue **the analysis based on the difference between the two options**. Operating costs, as well as operating income for a large investment, are considered from the capitalization of the investment for a reference period of 15 years. Operating costs were calculated based on the data provided by FLUVIUS Ltd.

The following cost types were distinguished in the analysis:

- *Personnel expenses:* gross wages and salaries of employees of the Operator's work organization working on the vessel directly affected by the project, including wage contributions. In determining future values, we calculated a 4% annual increase in real wages. For personnel expenses, the base year 2019 was EUR 265,109.24.
- *Operating costs:* material costs not related to personnel and maintenance costs incurred by the Operator. In determining future values, we calculated an annual growth of 4%. (in a real sense). In the case of large investments, fuel costs were highlighted from operating costs, given that there is a significant change in this line, compared to an annual increase of 4%. The study carried out during the development of the concept predicts an 8% reduction in fuel demand, according to which we calculated the fuel costs of previous years by 8% after the investment, inflation. For operating costs, the base year was 2019, which amounted to EUR 630,781.16.
- *Maintenance costs:* costs incurred by the Operator for the maintenance of the ship. In determining future values, we calculated an annual growth of 4%. (in a real sense). For maintenance costs, the average of 2019 repair costs for each ship was the equivalent of EUR 19,716.53.

Replacement costs

Methodology for estimating replacement costs

Replacement costs were estimated based on the data provided by the bidder and the experience of FLUVIUS Ltd. In the case of a small investment, as shown in the table below, there is an annual replacement cost of EUR 3000, which is the cost of renovating the hatch covers and installing UV-

resistant tarpaulins. In the case of a large investment, the solar system will have to be re-installed in 2032, according to which the relevant investment cost will be incurred again, amounting to EUR 34, 766.67. The service life of the solar system was estimated according to the manufacturer's information.

Summary of financial income

Methodology for estimating financial income

The financial revenues per ship were calculated based on the data provided by FLUVIUS Ltd. The calculation is based on the average of the revenues from Melanie and its associated barges in the last 3 closed fiscal years.

The unit revenue used in the calculation for MS Melanie was EUR 922,088.56, which was calculated as an annual increase of 4%.

In the case of small and large investments, the income is unchanged, so the difference will always be EUR 0.

Financial residual value

The current cost-benefit analysis is a cash-flow analysis, according to which we have calculated only those items that are realized financially. Given that it does not plan to sell the vessels after the reference period, no residual value income will be realized during the investment, according to which the residual value was not considered in the calculation. The disregard of the residual value is regulated by the GBER Regulation.[1]

The financial return on a large investment

The two most important return indicators in the financial analysis are the financial net present value of the project and the internal rate of return.

FNPV (financial net present value)

- shows whether the project will pay off in the 15-year reference period.

FRR (internal rate of return)

- the rate of return on the project, showing the return on investment (investment) over the 15-year reference period, considering the average expected return on investment. If the FNPV is negative, its value is lower than the 4% discount rate used.

The following table shows the financial return on a large investment.

Year	Financial investment cost	Financial operating cost	Total financial costs	Financial income	Financial income Total	Net cash flow	Net present value	Financial internal rate of return
FPV	185209,2	-763157	-577948	0	0	577947,9	577947,9	33%
2020	0	0	0	0	0	0		

[1] https://eur-lex.EURpa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:02014R0651-20170710&from=EN#tocId9

Year	Financial investment cost	Financial operating cost	Total financial costs	Financial income	Financial income Total	Net cash flow	Net present value	Financial internal rate of return
2021	0	0	0	0	0	0		
2022	200322,2	0	200322,2	0	0	-200322		
2023	0	-59364,91	-59364,9	0	0	59364,91		
2024	0	-61619,51	-61619,5	0	0	61619,51		
2025	0	-63964,29	-63964,3	0	0	63964,29		
2026	0	-66402,86	-66402,9	0	0	66402,86		
2027	0	-68938,97	-68939	0	0	68938,97		
2028	0	-71576,53	-71576,5	0	0	71576,53		
2029	0	-74319,59	-74319,6	0	0	74319,59		
2030	0	-77172,38	-77172,4	0	0	77172,38		
2031	0	-80139,27	-80139,3	0	0	80139,27		
2032	0	-83224,84	-83224,8	0	0	83224,84		
2033	0	-86433,84	-86433,8	0	0	86433,84		
2034	0	-89771,19	-89771,2	0	0	89771,19		
2035	0	-58475,37	-58475,4	0	0	58475,37		
2036	0	-96851,72	-96851,7	0	0	96851,72		
2037	0	-100605,8	-100606	0	0	100605,8		

4. Table: Calculation of return on investment (difference, EUR) (Concept1)

Sustainability of the investment

The examination of financial sustainability must demonstrate that the financial liquidity of the project owner is ensured during the period under review, i.e. taking into account all other expenditure and revenue cash flows not yet taken into account in the financial analysis, the accumulated net cash flow will not be negative in any year.

Based on this financial sustainability analysis, it can be concluded that the implementation of the project does not require additional resources, the accumulated cash flow will not be negative in any of the years.

Determination of the aid amount

Under Article 36 of the GBER Regulation, the aid intensity may not exceed 40% of the eligible costs, which may be increased by 20 percentage points for aid to small enterprises. FLUVIUS Ltd. Qualifies as a small enterprise, so in total 60% of the difference between large and small investments can be calculated as a subsidy amount. This is illustrated in the table below. Overall, the aid intensity for this concept is 59%.

Name		EUR
High investment cost		200 322,22 €
Low investment cost		3 000,00 €
Difference cost		197 322,22 €
GBER aid intensity		60%
base	40%	78 928,89 €
for small enterprises	20%	39 464,44 €
Grant amount requested		118 393,33 €
Aid intensity		59%

5. Table: Aid amount (Concept1)

3.1.3 Main conclusions

Installation of solar panels is feasible, technically possible, FLUVIUS would implement the concept not only on Melanie-H, but on other vessels as well.

By completing the replacement of the auxiliary engine and solar power system on the MS MELANIE-H river cargo ship, additional fuel consumption-based air emissions reductions can be achieved compared to the current ship's auxiliary engine emissions.

3.2 Hybrid propulsion

In the second concept, we examined the associated costs of hybrid propulsion engines, their installation, and the costs of engine room rearrangements. The costs of planning and permitting were also considered in the analysis. The concept also presented a battery-powered and non-battery-powered version, from which we analyzed the battery-powered version according to the project owner's decision. The battery version solution also requires the conversion of the hull, the design, licensing, and construction costs of which have also been considered and estimated based on experience.

As a basis for comparing the project developed in the concept, we present Concept 4 as a small investment, adjusting its values to Johanna's operating costs and revenues.

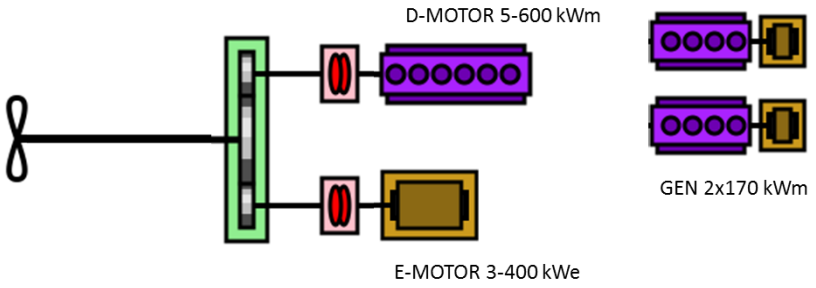
3.2.1 History

On the vessel MS Johanna, a partial operational profile survey was conducted in September 2019, when the power of the vessel's main engine was recorded for about 2 weeks in context of speed. Speed values

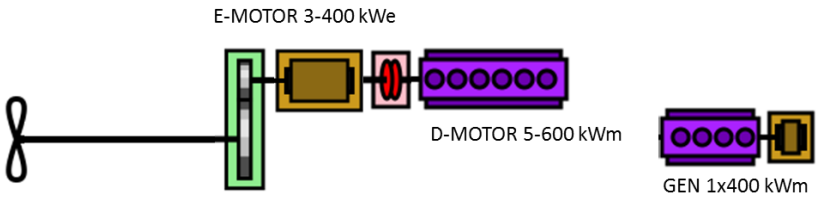
were calculated from GPS transmitter position data and time difference. As additional useful information, the ship's load and water levels were available from the FLUVIUS database. The measured data cannot be considered relevant in all respects but are in any case suitable for giving an idea of the nature of the vessel's operation on the Rhine-Main waterways. The measured data clearly show the difference between the upstream and downstream course.

The experts examined the performance of the current main engine and auxiliary equipment on the vessel. Considering the engine performances and the preferences of FLUVIUS, the experts collected the possible motors and generators. The concepts of two different Diesel-electric systems and a hybrid system were developed by the experts and then evaluated.

The least additional mechanical equipment is needed for the hybrid version, this presumably fits in the ship with a generator for 1 or 2 drives. Redundancy is also ensured here; the power levels can be well matched to the operational profile of the vessel.



2. Figure: Hybrid system version A



3. Figure: Hybrid system - version B

3.2.2 Cost-benefit analysis

Investment costs

The investment costs are presented separately for the two cases.

Investment costs	Gross price	Net price	VAT
Hybrid motor with battery	1 136 675,40 €	895 020,00 €	241 655,40 €
Ship extension costs and engine installation costs	381 000,00 €	300 000,00 €	81 000,00 €
Relocation costs	12 700,00 €	10 000,00 €	2 700,00 €
Electrical network renovation	65 746,90 €	51 769,21 €	13 977,69 €

Investment costs	Gross price	Net price	VAT
Total assets and construction	**1 596 122,30 €**	**1 256 789,21 €**	**339 333,09 €**
Design costs	78 531,97 €	61 836,20 €	16 695,77 €
Licensing costs	1 270,00 €	1 000,00 €	270,00 €
Total services	**79 801,97 €**	**62 836,20 €**	**16 965,77 €**
Total investment costs	**1 675 924,27 €**	**1 319 625,41 €**	**356 298,86 €**

6. Table: Investment costs for large investments (Concept2)

Investment costs	Gross price	Net price	VAT
W14 main engine replacement and additional system	476 250,00 €	375 000,00 €	101 250,00 €
Gearbox installation	254 000,00 €	200 000,00 €	54 000,00 €
Propeller	25 400,00 €	20 000,00 €	5 400,00 €
Propeller shaft with bearings	19 050,00 €	15 000,00 €	4 050,00 €
Total assets and construction	**774 700,00 €**	**610 000,00 €**	**164 700,00 €**
Licensing cost	1 270,00 €	1 000,00 €	270,00 €
Design costs	52 070,00 €	41 000,00 €	11 070,00 €
Installation and other costs	63 500,00 €	50 000,00 €	13 500,00 €
Wages	38 100,00 €	30 000,00 €	8 100,00 €
Total services	**154 940,00 €**	**122 000,00 €**	**32 940,00 €**
Total investment cost	**929 640,00 €**	**732 000,00 €**	**197 640,00 €**

7. Table: Investment costs for small investment (Concept2)

In both cases, all cost items can be accounted for, so there is no investment element or service of which value should not be considered in subsequent calculations. Investment costs would be incurred in 2022.

The cost of assets and services has been determined based on quotations or experience. Reconstruction costs were estimated based on the costs of previous reconstruction and relocation work. In the case of licensing, we estimated the costs based on official fees, and in the case of design, we relied on the estimation of the design team that compiled the technical content.

We plan to implement the project in 2022. We plan to activate the investment by 2023.

Operational costs

Operational costs are presented according to the development difference (incremental) method for both the small investment and the large investment variants, and then we continue the analysis based on the difference between the two variants. Operating costs, as well as operating income for a large investment, are considered from the capitalization of the investment for a reference period of 15 years. Operating costs were calculated based on the data provided by FLUVIUS Ltd.

The following cost types were distinguished in the analysis:

- *Personnel expenses:* gross wages and salaries of employees of the Operator's work organization working on the vessel directly affected by the project, including wage contributions. In determining future values, we calculated a 4% annual increase in real wages. For personnel expenses, the base year was 2019, which amounted to EUR 177,044.71.
- *Operating costs:* material costs not related to personnel and maintenance costs incurred by the Operator. In determining future values, we calculated an annual growth of 4%. (in a real sense). In the case of large investments, fuel costs were singled out from operating costs, given that there is a significant change in this line, compared to an annual increase of 4%. The study carried out during the elaboration of the concept predicts a 30-40% reduction in fuel demand, according to which we calculated 70% of the fuel costs of previous years after the investment, inflating it. For operating costs, the base year was 2019, which amounted to EUR 48,512.42, which, for the above reasons, does not yet include fuel costs. The vessel is typically leased by FLUVIUS Ltd., therefore, the fuel costs arising from the specific transport activity are not incurred by FLUVIUS. However, since the implementation of a large investment mainly affects the fuel cost, we have therefore shown it in the analysis based on previous experience values. In the case of cumulated cash flow, this will not be a false result, given that the cost of fuel has also been included in revenues. The display of the exact fuel cost is also significant.
- *Maintenance costs:* costs incurred by the Operator for the maintenance of the ship. In determining future values, we calculated an annual growth of 4%. (in a real sense). For maintenance costs, the average of 2019 repair costs for each ship was the equivalent of EUR 19,716.53.

Replacement costs

Methodology for estimating replacement costs

Replacement costs were estimated based on the experience of FLUVIUS Ltd. There is no replacement cost for either the large or the small investment, the annual maintenance costs ensure the integrity of the rebuilt, repaired hull during the reference period.

Summary of financial income

Methodology for estimating financial income

The financial revenues per vessel were calculated based on the data provided by FLUVIUS Ltd. The calculation is based on the average revenue from the rental of MS Johanna in the last 3 closed financial years. For financial revenues, fuel costs are included in the concept of operating costs.

The unit revenue used in the calculation for MS Johanna was EUR 335,098.15, which was calculated with an annual increase of 4%.

In the case of small and large investments, the income is unchanged, so the difference will always be EUR 0.

Financial residual value

The current cost-benefit analysis is a cash-flow analysis, according to which we have calculated only those items that are realized financially. Given that it does not plan to sell the vessel after the reference period, no residual value income will be realized during the investment, according to which the residual value was not considered in the calculation. The disregard of the residual value is regulated by the GBER Regulation.[2]

The financial return on a large investment

The two most important return indicators in the financial analysis are the financial net present value of the project and the internal rate of return.

FNPV (financial net present value)

- shows whether the project will pay off in the 15-year reference period.

FRR (internal rate of return)

- the rate of return on the project, showing the return on investment (investment) over the 15-year reference period, considering the average expected return on investment. If the FNPV is negative, its value is lower than the 4% discount rate used.

The following table shows the financial return on a large investment.

Year	Financial investment cost	Financial operating cost	Total financial costs	Financial income	Financial income Total	Net cash flow	Net present value	Financial internal rate of return
FPV	1220068	-563175	656893,3	0	0	-656893	-656893	-3%
2020	0	0	0	0	0	0		
2021	0	0	0	0	0	0		
2022	1319625	0	1319625	0	0	-1319625		
2023	0	-27796,1	-27796,1	0	0	27796,11		
2024	0	-28908	-28908	0	0	28907,95		
2025	0	-30064,3	-30064,3	0	0	30064,27		
2026	0	-31266,8	-31266,8	0	0	31266,84		
2027	0	-32517,5	-32517,5	0	0	32517,51		
2028	0	-33818,2	-33818,2	0	0	33818,21		
2029	0	-35170,9	-35170,9	0	0	35170,94		

[2] https://eur-lex.EURpa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:02014R0651-20170710&from=EN#tocId9

Year	Financial investment cost	Financial operating cost	Total financial costs	Financial income	Financial income Total	Net cash flow	Net present value	Financial internal rate of return
2030	0	-36577,8	-36577,8	0	0	36577,78		
2031	0	-38040,9	-38040,9	0	0	38040,89		
2032	0	-39562,5	-39562,5	0	0	39562,53		
2033	0	-41145	-41145	0	0	41145,03		
2034	0	-42790,8	-42790,8	0	0	42790,83		
2035	0	-44502,5	-44502,5	0	0	44502,46		
2036	0	-46282,6	-46282,6	0	0	46282,56		
2037	0	-423134	-423134	0	0	423133,9		

8. **Table: Calculation of return on investment (EUR difference) (Concept2)**

Sustainability of the investment

The examination of financial sustainability must demonstrate that the financial liquidity of the project owner is ensured during the period under review, i.e. taking into account all other expenditure and revenue cash flows not yet taken into account in the financial analysis, the accumulated net cash flow will not be negative in any year. provided.

Based on this financial sustainability analysis, it can be concluded that the net accumulated financial cash flow is positive every year, so the sustainability of the project is financially ensured, the involvement of external sources is not necessary.

Determination of the aid amount

Under Article 36 of the GBER Regulation, the aid intensity may not exceed 40% of the eligible costs, which may be increased by 20 percentage points for aid to small enterprises. FLUVIUS Ltd. qualifies as a small enterprise, so in total 60% of the difference between large and small investments can be calculated as a subsidy amount. This is illustrated in the table below. Overall, the aid intensity for this concept is 27%.

Name	EUR
High investment cost	1 319 625,41 €
Low investment cost	732 000,00 €
Difference cost	587 625,41 €
GBER aid intensity	60%

Name		EUR
base	40%	235 050,16 €
for small enterprises	20%	117 525,08 €
Grant amount requested		352 575,25 €
Aid intensity		27%

9. Table: Aid amount (Concept2)

3.2.3 Main conclusions

Based on all - by no means complete - information, it can be stated with great certainty that the hybrid system can be said to be more favourable compared to the diesel electric versions due to economic and certain technical aspects. Considering the hybrid variations as well, a version of the parallel hybrid system without a unifying gear can be recommended for the conversion of MS JOHANNA, even supplemented with batteries. Note that even with this version, the individual system components can be changed according to the needs, which obviously affects the price and return of the system.

3.3 Hull conversion

In connection with the third concept, which examines the investment related to hull conversion for MS Ulm, we also identified small and large investment options.

While for the large investment, in addition to the total hull conversion cost, design and licensing costs were also considered. Until then, the small investment is only calculated by replacing the "running out" corrosive plates.

3.3.1 History

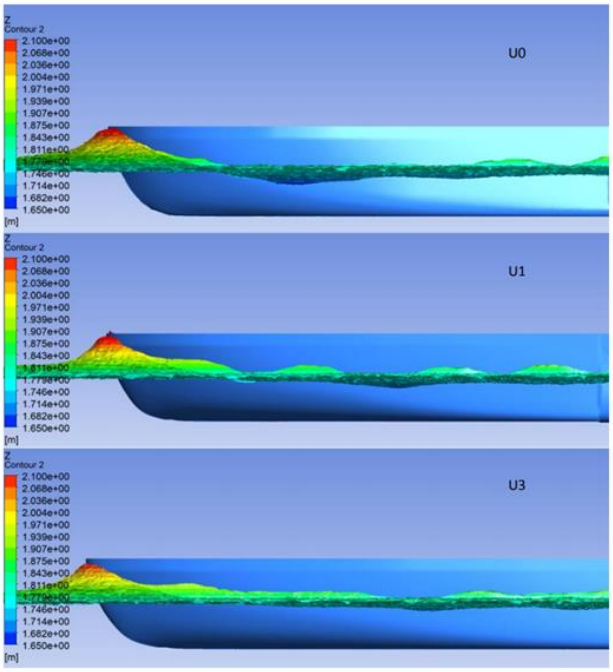
After survey of the hull, a hydrodynamic analysis was made by the experts on the MS Ulm. The main findings of the hydrodynamic analysis can be summarized as follows:

- a more hydrodynamically favourable design can be achieved by slimming the nose, which in turn would lead to a reduction in the front of the load compartment and the load capacity,
- it is therefore advisable to adapt the variable cross-section of the bow of the vessel by extension,
- from a hydrodynamic point of view, it does not seem necessary to increase the length of the ship to 110 m, even with an increase of 2-3 m we can get a more favourable shape than at present, so that the front of the cargo space can remain in its current form,
- based on the analytical resistance calculation, each of the new versions is at least approx. can mean a 15% effective power reduction.

Based on these findings, the experts created three different suggestions, from which the U3 variant was chosen for further development. Features of the U3 version:

- U3 - a new bow-shaped ship with a length of 108 m - this version was made by stretching the U1 in order to make the curves even finer, but the protrusion of the cargo space should not be as large as in the case of the U1, due to the stretching it is even smaller here. there would be water displacement, but this is compensated by increasing the length, the extra water

displacement and space obtained in this way can also give the possibility of a possible extension of the cargo space here (of course only with a reduced width).



4. Figure: U0, U1 and U3 variants of hull conversion

3.3.2 Cost-benefit analysis

Investment costs

The investment costs are presented separately for the two cases.

Activity	Total cost	Total net cost	VAT
1. Acquisition of assets	**0,00 €**	**0,00 €**	**0,00€**
1.1 Replacing "Running Out" Corrosive Plates	0,00 €	0,00 €	0,00 €
2. Services	**356 870,00 €**	**281 000,00 €**	**75 870,00 €**
2.1 Licensing costs	1 270,00 €	1 000,00 €	270,00 €
2.2 Design costs	38 100,00 €	30 000,00 €	8 100,00 €
2.3 Hull conversion costs	317 500,00 €	250 000,00 €	67 500,00 €
3. Reserve	**0,00 €**	**0,00 €**	**0,00€**
4. Total	**356 870,00 €**	**281 000,00 €**	**75 870,00 €**

10. Table: Investment costs for large investments (Concept3)

Activity	Total cost	Total net cost	VAT
1. Acquisition of assets	**133 350,00 €**	**105 000,00 €**	**28 350,00 €**
1.1 Replacing "Running Out" Corrosive Plates	133 350,00 €	105 000,00 €	28 350,00 €
2. Services	**-**	**-**	**-**
2.1 Licensing costs	-	-	-
2.2 Design costs	-	-	-
2.3 Hull conversion costs	-	-	-
3. Reserve	**-**	**-**	**-**
4. Total	**133 350,00 €**	**105 000,00 €**	**28 350,00 €**

11. Table: Investment costs for small investments (Concept3)

In both cases, all cost items can be accounted for, so there is no investment element or service of which value should not be considered in subsequent calculations.

After that, the investment costs were calculated in annual breakdown, broken down by cost categories for both small and large investments.

Volume of price of equipment and services: the costs of equipment and services were determined by FLUVIUS Ltd. based on price offers or previous experience. Reconstruction costs were estimated based on the costs of previous reconstruction and relocation work. In the case of licensing, we estimated the costs based on official fees, and in the case of design, we relied on the estimation of the design team that compiled the technical content.

The implementation of the project is scheduled for 2022. We plan to activate the investment by 2023.

Operational costs

Operational costs are presented according to the development difference (incremental) method for both the small investment and the large investment variants, and then we continue the analysis based on the difference between the two variants. Operating costs, as well as operating income for a large investment, are considered from the capitalization of the investment for a reference period of 15 years. Operating costs were calculated based on the data provided by FLUVIUS Ltd.

The following cost types were distinguished in the analysis:

- *Personnel expenses:* gross wages and salaries of employees of the Operator's work organization working on the vessel directly affected by the project, including wage contributions. In determining future values, we calculated a 4% annual increase in real wages.
- *Operating costs:* material costs not related to personnel and maintenance costs incurred by the Operator. In determining future values, we calculated an annual growth of 4%. (in a real sense).
- *Maintenance costs:* costs incurred by the Operator for the maintenance of the ship. In determining future values, we calculated an annual growth of 4%. (in a real sense).

Replacement costs

Methodology for estimating replacement costs

Replacement costs were estimated based on the experience of FLUVIUS Ltd. There are no replacement costs for either the large or the small investment, the annual maintenance costs ensure the integrity of the rebuilt, repaired hull during the reference period.

Summary of financial income

Methodology for estimating financial income

The financial income per vessel was calculated based on the previous reports of FLUVIUS Ltd. Revenue data from 2017 to 2019 were averaged and calculated later. In the calculation, the unit revenue used for MS Ulm from 2020 is EUR 390,046.75, which is calculated as an annual increase of 4%. Given that the income for small and large investments does not change, the difference will be EUR 0 each year.

Financial residual value

The current cost-benefit analysis is a cash-flow analysis, according to which we have calculated only those items that are realized financially. Given that it does not plan to sell the vessel after the reference period, no residual value income will be realized during the investment, according to which the residual value was not considered in the calculation. The disregard of the residual value is regulated by the GBER Regulation.[3]

The financial return on a large investment

The two most important return indicators in the financial analysis are the financial net present value of the project and the internal rate of return.

FNPV (financial net present value)

- shows whether the project will pay off in the 15-year reference period.

FRR (internal rate of return)

- the rate of return on the project, showing the return on investment (investment) over the 15-year reference period, considering the average expected return on investment. If the FNPV is negative, its value is lower than the 4% discount rate used.

The following table shows the financial return on a large investment.

Year	Financial investment cost	Financial operating cost	Total financial costs	Financial income	Financial income Total	Net cash flow	Net present value
FPV	259800,3	59278,19	319078,5	0	0	-319078,5	-0,319
2020	0	0	0	0	0	0	
2021	0	0	0	0	0	0	

[3] https://eur-lex.EURpa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:02014R0651-20170710&from=EN#tocId9

Year	Financial investment cost	Financial operating cost	Total financial costs	Financial income	Financial income Total	Net cash flow	Net present value
2022	281000	0	281000	0	0	-281000	
2023	0	4445,327	4445,327	0	0	-4445,33	
2024	0	4623,14	4623,14	0	0	-4623,14	
2025	0	4808,066	4808,066	0	0	-4808,07	
2026	0	5000,388	5000,388	0	0	-5000,39	
2027	0	5200,404	5200,404	0	0	-5200,4	
2028	0	5408,42	5408,42	0	0	-5408,42	
2029	0	5624,757	5624,757	0	0	-5624,76	
2030	0	5849,747	5849,747	0	0	-5849,75	
2031	0	6083,737	6083,737	0	0	-6083,74	
2032	0	6327,087	6327,087	0	0	-6327,09	
2033	0	6580,17	6580,17	0	0	-6580,17	
2034	0	6843,377	6843,377	0	0	-6843,38	
2035	0	7117,112	7117,112	0	0	-7117,11	
2036	0	7401,796	7401,796	0	0	-7401,8	
2037	0	7697,868	7697,868	0	0	-7697,87	

12. **Table: Calculation of return on investment (EUR difference) (Concept3)**

Sustainability of the investment

The examination of financial sustainability must demonstrate that the financial liquidity of the project owner is ensured during the period under review, i.e. taking into account all other expenditure and revenue cash flows not yet taken into account in the financial analysis, the cumulative net cash flow will not be negative in any year, financial balance is ensured.

Based on this financial sustainability analysis, it can be concluded that the net accumulated (cumulative) financial cash flow is positive every year, so the sustainability of the project is financially ensured.

Determination of the aid amount

Under Article 38 of the GBER Regulation, the aid intensity may not exceed 30% of the eligible costs, which may be increased by 20 percentage points for aid to small enterprises. FLUVIUS Ltd. Qualifies as a small enterprise, so in total 50% of the difference between large and small investments can be calculated as a subsidy amount. This is illustrated in the table below. Overall, the aid intensity for this concept is 31%.

Name		EUR
High investment cost		281 000,00 €
Low investment cost		105 000,00 €
Difference cost		176 000,00 €
GBER aid intensity		50%
base	30%	52 800,00 €
for small enterprises	20%	35 200,00 €
Grant amount requested		88 000,00 €
Aid intensity		31%

13. Table: Aid amount (Concept3)

3.3.3 Main conclusions

- Hull conversion is a rather costly concept; however, its return is uncertain.
- Cargo carrying capacity decrease or ship should be extended to make better hydrodynamic bow.
- There is no significant difference at draft of 1,8 or 2,3 meters.
- Ideal floating circumstance is at 5m water depth, which makes all calculation uncertain.
- If structure of the ship will be changed, it must be under register company's approval.
- Change of bow might bring 15% decrease in output needs, but it does not mean automatically same spare in fuel.

3.4 Main engine replacement

In connection with the fourth concept, which examines the investment related to the main engine replacement for MS Elsava, we also defined small and large investment variants.

While for the large investment, in addition to the cost of fully replacing the main engine, design and licensing costs were also considered. Until then, the small investment only counts on the cost of repairing the main engine.

3.4.1 History

FLUVIUS carried out a comprehensive environmental assessment for their fleet, including air loads (emissions), water pollution, wastewater generation, noise and vibration protection, waste

management, energy management, material flow, hazardous material use, total emissions – surveyed the total ecological footprint.

The emissions of the ship's main engine and auxiliary engine were measured and evaluated on two vessels of the FLUVIUS fleet. MS Elsava was selected for further development of the concept.

According to the experts' analysis, the operation of the new main engine could save the ship significant air pollutants compared to the old engine and, if fitted with a catalytic converter, this would be even more true, although it meets the strictest EU STAGE 5 and that CO_2 emissions could also be significantly reduced according to the basic data provided (531,178 kg vs 452,644 kg per hour).

5. Figure: MS Elsava

3.4.2 Cost-benefit analysis

Investment costs

Investment costs are presented separately for the two cases.

Activity	Total cost	Total net cost	VAT
1. Acquisition of assets	**774 700,00 €**	**610 000,00 €**	**164 700,00 €**
1.1 W14 main engine replacement and additional system	476 250,00 €	375 000,00 €	101 250,00 €
1.2 Gear unit installation	254 000,00 €	200 000,00 €	54 000,00 €

Activity	Total cost	Total net cost	VAT
1.3 Propeller	25 400,00 €	20 000,00 €	5 400,00 €
1.4 Propeller shaft with bearings	19 050,00 €	15 000,00 €	4 050,00 €
2. Services	**154 940,00 €**	**122 000,00 €**	**32 940,00 €**
2.1 Licensing costs	1 270,00 €	1 000,00 €	270,00 €
2.2 Design costs	52 070,00 €	41 000,00 €	11 070,00 €
2.3 Installation and other costs	63 500,00 €	50 000,00 €	13 500,00 €
2.4 Remuneration	38 100,00 €	30 000,00 €	8 100,00 €
3. Reserve	**0,00 €**	**0,00 €**	**0,00 €**
4. Total	**929 640,00 €**	**732 000,00 €**	**197 640,00 €**

14. Table: Investment costs for large investments (Concept4)

Activity	Total cost	Total net cost	VAT
1. Acquisition of assets	**190 500,00 €**	**150 000,00 €**	**40 500,00 €**
1.1 Repairing the main machine	190 500,00 €	150 000,00 €	40 500,00 €
1.2 Gear unit installation	0,00 €	0,00 €	0,00 €
1.3 Propeller	0,00 €	0,00 €	0,00 €
1.4 Propeller shaft with bearings	0,00 €	0,00 €	0,00 €
2. Services	**0,00 €**	**0,00 €**	**0,00 €**
2.1 Licensing costs	0,00 €	0,00 €	0,00 €
2.2 Design costs	0,00 €	0,00 €	0,00 €
2.3 Installation and other costs	0,00 €	0,00 €	0,00 €
2.4 Remuneration	0,00 €	0,00 €	0,00 €
3. Reserve	**0,00 €**	**0,00 €**	**0,00 €**
4. Total	**190 500,00 €**	**150 000,00 €**	**40 500,00 €**

15. Table: Investment costs for small investments (Concept4)

In both cases, all cost items are eligible, so there is no investment item or service of which value should not be included in subsequent calculations.

After that, the investment costs were calculated in annual breakdown, broken down by cost categories for both small and large investments.

Volume of price of equipment and services: the costs of equipment and services were determined by FLUVIUS Ltd. based on price offers or previous experience. Reconstruction costs were estimated based on the costs of previous reconstruction and relocation work. In the case of licensing, we estimated the costs based on the official fees, and in the case of design, we relied on the estimation of the design team that compiled the technical content.

The implementation of the project is scheduled for 2022. We plan to activate the investment by 2023.

Operational costs

Operational costs are presented according to the development difference (incremental) method for both the small investment and the large investment versions, and then we continue the analysis based on the difference between the two options. Operating costs, as well as operating income for a large investment, are considered from the capitalization of the investment for a reference period of 15 years. Operating costs were calculated based on the data provided by FLUVIUS Ltd.

The following cost types were distinguished in the analysis:

- *Personnel expenses:* gross wages and salaries of employees of the Operator's work organization working on the vessel directly affected by the project, including wage contributions. In determining future values, we calculated a 4% annual increase in real wages.
- *Operating costs:* material costs not related to personnel and maintenance costs incurred by the Operator. In determining future values, we calculated an annual growth of 4%. (in a real sense).
- *Maintenance costs:* costs incurred by the Operator for the maintenance of the ship. In determining future values, we calculated an annual growth of 4%. (in a real sense).

Replacement costs

Methodology for estimating replacement costs

Replacement costs were estimated based on the data provided by the bidder and the experience of FLUVIUS Ltd. for a small investment, there is no replacement cost, the annual maintenance costs ensure the safety of the vessel during the reference period. However, in the case of a large investment, the W14 main engine will need to be replaced after 15 years.

Summary of financial income

Methodology for estimating financial income

The financial income per vessel was *calculated* based on the previous reports of FLUVIUS Ltd., which was provided to us by the company. The last 10 closed financial years (2010 to 2019) were used as the basis for the calculation, and then the values thus obtained were averaged. The unit revenue used in the calculation for MS Elsava from 2020 onwards is EUR 485,680.14, which is calculated as an annual increase of 4%. There is no difference between the income of large and small investments, the difference is 0 EUR each year.

Financial residual value

The current cost-benefit analysis is a cash-flow analysis, according to which we have calculated only those items that are realized financially. Given that it does not plan to sell the vessel after the reference

period, no residual value income will be realized during the investment, according to which the residual value was not considered in the calculation. The disregard of the residual value is regulated by the GBER Regulation.[4]

The financial return on a large investment

The two most important return indicators in the financial analysis are the financial net present value of the project and the internal rate of return.

FNPV (financial net present value)

- shows whether the project will pay off in the 15-year reference period.

FRR (internal rate of return)

- the rate of return on the project, showing the return on investment (investment) over the 15-year reference period, considering the average expected return on investment. If the FNPV is negative, its value is lower than the 4% discount rate used.

The following table shows the financial return on a large investment.

Year	Financial investment cost	Financial operating cost	Total financial costs	Financial income	Financial income Total	Net cash flow	Net present value	Financial internal rate of return
FPV	676775,1	-597492	79282,71	0	0	-79282,7	-0,079	2%
2020	0	0	0	0	0	0		
2021	0	0	0	0	0	0		
2022	732000	0	732000	0	0	-732000		
2023	0	-37307,4	-37307,4	0	0	37307,42		
2024	0	-38799,7	-38799,7	0	0	38799,72		
2025	0	-79284,6	-79284,6	0	0	79284,6		
2026	0	-41965,8	-41965,8	0	0	41965,78		
2027	0	-43644,4	-43644,4	0	0	43644,41		
2028	0	-52233	-52233	0	0	52233,03		
2029	0	-47205,8	-47205,8	0	0	47205,79		
2030	0	-93501,4	-93501,4	0	0	93501,35		
2031	0	-51057,8	-51057,8	0	0	51057,78		
2032	0	-53100,1	-53100,1	0	0	53100,09		
2033	0	-56889,2	-56889,2	0	0	56889,17		
2034	0	-57433,1	-57433,1	0	0	57433,06		
2035	0	-117361	-117361	0	0	117360,6		
2036	0	-62119,6	-62119,6	0	0	62119,6		
2037	0	-64604,4	-64604,4	0	0	64604,38		

[4] https://eur-lex.EURpa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:02014R0651-20170710&from=EN#tocId9

16. Table: Calculation of return on investment (EUR difference) (Concept4)

Sustainability of the investment

The examination of financial sustainability must demonstrate that the financial liquidity of the project promoter must be ensured during the period under review, i.e. the various cash flows of expenditure and revenue have not been taken into account in all financial analyses when the cumulative net cash flow is negative in one year. balance is ensured.

Based on this financial sustainability analysis, it can be concluded that the net accumulated (cumulative) financial cash flow is positive every year, so the sustainability of the project is financially ensured.

Determination of the aid amount

Under Article 36 of the GBER Regulation, the aid intensity may not exceed 40% of the eligible costs, which may be increased by 20 percentage points for aid to small enterprises. FLUVIUS Ltd. qualifies as a small enterprise, so in total 60% of the difference between large and small investments can be calculated as a subsidy amount. This is illustrated in the table below. Overall, the aid intensity for this concept is 48%.

Name		EUR
High investment cost		732 000,00 €
Low investment cost		150 000,00 €
Difference cost		582 000,00 €
GBER aid intensity		60%
base	40%	232 800,00 €
for small enterprises	20%	116 400,00 €
Grant amount requested		349 200,00 €
Aid intensity		48%

17. Table: Aid amount (Concept4)

3.4.3 Main conclusions

The possible reduction in bunker consumption is 10-15%, which means similar reduction in quantity of exhaust gases.

It has been revealed that old engines emission values are not dramatically different from the Stage5 engine – NO_x are higher. In 2020 stage5 engines does not exist by their own, therefore exhaust gas treating equipment must be added. The price of the exhaust treater system is almost the same (90%) as the price of the main engine.

3.5 Electricity network renovation

In connection with the fifth concept, which examines the investment related to the renovation of the electricity network for MS Johanna, we also identified small and large investment variants.

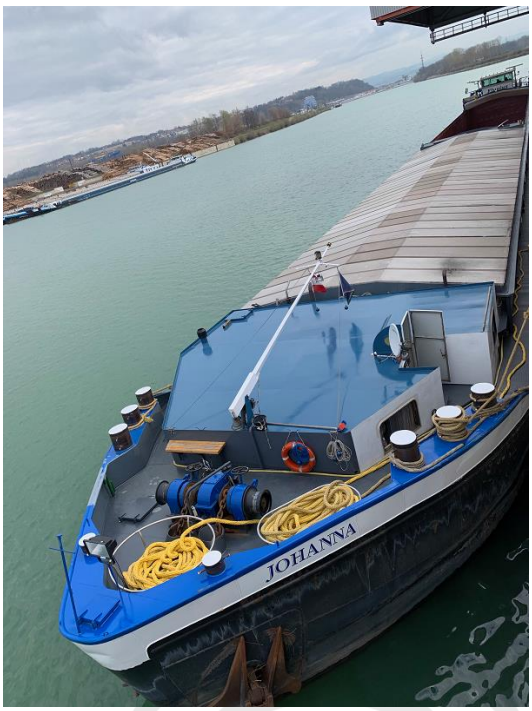
While for a large investment, in addition to a comprehensive electrical renovation cost, design and licensing costs were also considered. Until then, the small investment only counts a one-year fee associated with inspecting endpoint equipment.

3.5.1 History

Four ships from the FLUVIUS fleet were examined in the context of the electrical system, available energy sources, the energy distribution system and considering the specificities of energy use have been documented.

It is advisable to use electricity in the most economical way, hence the formula based, if the “Reactive Power” is reduced to zero, then the electric “Apparent Power” taken from the network is equal to the “Watt-Power” performing useful work. Reducing “Reactive Power” is called phase correction. The installation of capacitive elements can be a solution to eliminate this. Using so-called "phase correctors" or “phase improvers”, incorporating capacitors, this adverse effect can be reduced, and network losses can be optimized.

MS Johanna was chosen for the development of the concept. MS Johanna was built in 1908, the electrical systems then developed later they were replaced by more modern ones during the renovation.



6. Figure: MS Johanna

3.5.2 Cost-benefit analysis

Investment costs

Investment costs are presented separately for the two cases.

Activity	Total cost	Total net cost	VAT
1. Acquisition of assets	**34 491,76 €**	**27 158,87 €**	**7 332,89 €**
1.1 Simplification of the elements of a 24V distribution system, replacement with more modern devices	12 154,78 €	9 570,69 €	2 584,09 €
1.2 Partial cable network replacement	20 836,75 €	16 406,89 €	4 429,86 €
1.3 Phase correction	458,41 €	360,95 €	97,46 €
1.4 Lighting upgrade	1 041,83 €	820,34 €	221,49 €
2. Services	**41 207,11 €**	**32 446,54 €**	**8 760,57 €**
2.1 Licensing costs	1 270,00 €	1 000,00 €	270,00 €
2.2 Design costs	8 681,97 €	6 836,20 €	1 845,77 €
2.3 Installation of central energy control and distribution PLC system	31 255,13 €	24 610,34 €	6 644,79 €
2.4 Remuneration	**0,00 €**	**0,00 €**	**0,00 €**
3. Reserve	**0,00 €**	**0,00 €**	**0,00 €**
4. Total	**75 698,87 €**	**59 605,41 €**	**16 093,46 €**

18. Table: Investment costs for large investments (Concept5)

Activity	Total cost	Total net cost	VAT
1. Acquisition of assets	**0,00 €**	**0,00 €**	**0,00 €**
1.1 Simplification of the elements of a 24V distribution system, replacement with more modern devices	0,00 €	0,00 €	0,00 €
1.2 Partial cable network replacement	0,00 €	0,00 €	0,00 €
1.3 Phase correction	0,00 €	0,00 €	0,00 €
1.4 Lighting upgrade	0,00 €	0,00 €	0,00 €
2. Services	**2 951,87 €**	**2 324,31 €**	**627,56 €**
2.1 Licensing costs	0,00 €	0,00 €	0,00 €

Activity	Total cost	Total net cost	VAT
2.2 Design costs	0,00 €	0,00 €	0,00 €
2.3 Installation of central energy control and distribution PLC system	0,00 €	0,00 €	0,00 €
2.4 Remuneration	2 951,87 €	2 324,31 €	627,56 €
3. Reserve	**0,00 €**	**0,00 €**	**0,00 €**
4. Total	**2 951,87 €**	**2 324,31 €**	**627,56 €**

19. Table: Investment costs for small investments (Concept5)

In both cases, all cost items can eligible, so there is no investment element or service which's value should not be considered in subsequent calculations.

Volume of price of equipment and services: the costs of equipment and services were determined by FLUVIUS Ltd. based on price offers or previous experience. For equipment acquisition and installation, and for licensing and design, we relied on the estimation of the design team that compiled the technical content.

The implementation of the project is scheduled for 2022. We plan to activate the investment by 2023.

Operational costs

Operational costs are presented according to the development difference (incremental) method for both the small investment and the large investment versions, and then we continue the analysis based on the difference between the two options. Operating costs, as well as operating income for a large investment, are considered from the capitalization of the investment for a reference period of 15 years. Operating costs were calculated based on the data provided by FLUVIUS Ltd.

The following cost types were distinguished in the analysis:

- *Personnel expenses:* gross wages and salaries of employees of the Operator's work organization working on the vessel directly affected by the project, including wage contributions. In determining future values, we calculated a 4% annual increase in real wages.
- *Operating costs:* material costs not related to personnel and maintenance costs incurred by the Operator. In determining future values, we calculated an annual growth of 4%. (in a real sense).
- *Maintenance costs:* costs incurred by the Operator for the maintenance of the ship. In determining future values, we calculated an annual growth of 4%. (in a real sense).

Replacement costs

Methodology for estimating replacement costs

Replacement costs were estimated based on the data provided by the bidder and the experience of FLUVIUS Ltd. There is no replacement cost for either the large or the small investment, the annual maintenance costs ensure the safety of the refurbished vessel during the reference period.

Summary of financial income

Methodology for estimating financial income

The financial income per vessel was calculated based on the previous reports of Fluvius Kft., Which was provided by the company. Revenue data from 2017 to 2019 were averaged and calculated later. In the calculation, the unit revenue used for MS Johanna from 2020 onwards is EUR 348,502.08, calculated as an annual increase of 4%.

However, in the case of a large investment, in addition to the 5% increase in the revenue calculated during the small investment, the annual fuel cost of the large investment was also shown as revenue, as according to the charter model of the vessel, this cost is paid by the lessee. The summary of the financial costs and revenues of a large investment is illustrated in the table below.

Financial residual value

The current cost-benefit analysis is a cash-flow analysis, according to which we have calculated only those items that are realized financially. Given that it does not plan to sell the vessel after the reference period, no residual value income will be realized during the investment, according to which the residual value was not considered in the calculation. The disregard of the residual value is regulated by the GBER Regulation.[5]

The financial return on a large investment

The two most important return indicators in the financial analysis are the financial net present value of the project and the internal rate of return.

FNPV (financial net present value)

- shows whether the project will pay off in the 15-year reference period.

FRR (internal rate of return)

- the rate of return on the project, showing the return on investment (investment) over the 15-year reference period, considering the average expected return on investment. If the FNPV is negative, its value is lower than the 4% discount rate used.

The following table shows the financial return on a large investment.

Year	Financial investment cost	Financial operating cost	Total financial costs	Financial income	Financial income Total	Net cash flow	Net present value	Financial internal rate of return
FPV	55108,55	-157462	-102353	2575132	2575132	2677485	2,677	348%
2020	0	0	0	0	0	0		
2021	0	0	0	0	0	0		
2022	59605,41	0	59605,41	0	0	-59605,4		
2023	0	-11808,2	-11808,2	193111,5	193111,5	204919,7		

[5] https://eur-lex.EURpa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:02014R0651-20170710&from=EN#tocId9

Year	Financial investment cost	Financial operating cost	Total financial costs	Financial income	Financial income Total	Net cash flow	Net present value	Financial internal rate of return
2024	0	-12280,5	-12280,5	200836	200836	213116,5		
2025	0	-12771,7	-12771,7	208869,4	208869,4	221641,2		
2026	0	-13282,6	-13282,6	217224,2	217224,2	230506,8		
2027	0	-13813,9	-13813,9	225913,2	225913,2	239727,1		
2028	0	-14366,5	-14366,5	234949,7	234949,7	249316,2		
2029	0	-14941,1	-14941,1	244347,7	244347,7	259288,8		
2030	0	-15538,8	-15538,8	254121,6	254121,6	269660,4		
2031	0	-16160,3	-16160,3	264286,5	264286,5	280446,8		
2032	0	-16806,7	-16806,7	274857,9	274857,9	291664,7		
2033	0	-17479	-17479	285852,3	285852,3	303331,3		
2034	0	-18178,2	-18178,2	297286,3	297286,3	315464,5		
2035	0	-18905,3	-18905,3	309177,8	309177,8	328083,1		
2036	0	-19661,5	-19661,5	321544,9	321544,9	341206,4		
2037	0	-20448	-20448	334406,7	334406,7	354854,7		

20. Table: Calculation of return on investment (EUR difference) (Concept5)

Sustainability of the investment

The examination of financial sustainability must demonstrate that the financial liquidity of the project owner is ensured during the period under review, i.e. taking into account all other cash flows of expenditure and revenue not yet taken into account in the financial analysis, the cumulative net cash flow will not be negative in any year, financial balance is ensured.

Based on this financial sustainability analysis, it can be concluded that the net accumulated (cumulative) financial cash flow is positive every year, so the sustainability of the project is financially ensured.

Determination of the aid amount

Under Article 36 of the GBER Regulation, the aid intensity may not exceed 40% of the eligible costs, which may be increased by 20 percentage points for aid to small enterprises. FLUVIUS Ltd. qualifies as a small enterprise, so in total 60% of the difference between large and small investments can be calculated as a subsidy amount. This is illustrated in the table below. Overall, the aid intensity for this concept is 58%.

Name		EUR
High investment cost		59 605,41 €
Low investment cost		2 324,31 €
Difference cost		57 281,10 €
GBER aid intensity		60%
base	40%	22 912,44 €
for small enterprises	20%	11 456,22 €
Grant amount requested		34 368,66 €
Aid intensity		58%

21. Table: Aid amount (Concept5)

3.5.3 Main conclusions

Maintaining the proper condition of existing energy sources by the machines intended to maintain the value of the electrical power output. With the correction of the distribution system it is 2-9%, with the modernization of the lighting consumers, a further 16-21% reduction can be achieved in renewable energy without entering. By increasing the storage capacity as a function of the bridging time 16-34% savings over 12 hours of operation, alternative using energy supply.

Investing in phase improvers is not only beneficial from a consumption and environmental point of view, but a profitable investment. Fluvius plans to implement it on all ships.

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Annex 1.

Development of innovative and greening inland vessel concepts

FLUVIUS

Presentation held by András Kiss (Fluvius) at the GRENDEL Final Event (29 October 2020)

Project co-funded by European Union Funds (ERDF, IPA)

Greening! What to do first?

Made a brainstorming at start of project and following issues found to be investigate:

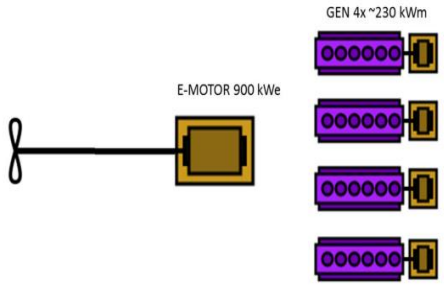
1. **change of main engines?**
2. **hybrid ship, diesel-electric ship?**
3. **greening of auxiliary power generation?**
    a) solar panels
    b) developing performance optimized electric system with phase correction devices
4. **Hull conversion?**

We carried out environmental survey for the fleet: Air loads (emissions), water pollution, wastewater generation, noise and vibration protection, waste management, energy management, material flow, hazardous material use, total emissions – surveyed the total ecological footprint.

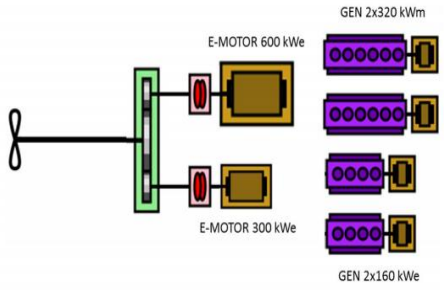
1. Modern engines (+ higher cargo carring capacity) versus old engines fuel consumption

	2018			
ship	**tokm**	**bunker (liters)**	lit/tokm(1000)	**extra consumption**
Elsava	19 631 394	196 059	**9,99**	144%
Johanna	20 336 803	257 587	**12,67**	183%
Ulm	16 761 717	167 003	**9,96**	144%
Melanie H	16 339 371			
SL Melanie	16 313 860			
SL 1043	1 643 814			
SL 1433	624 178			
54 barge (Melanie H)	6 980 324			
997 barge (Melanie H)	10 684 399			
	52 585 946	364 925	**6,94**	100%
modern truck	***2400***	***33***	***13,75***	

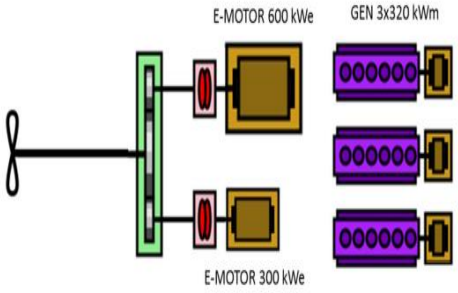
2. Diesel-electric and hybrid layouts



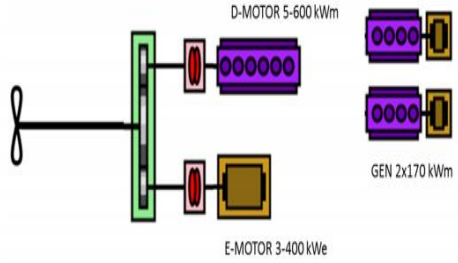
11. ábra: A DE1 hajtásrendszer sémája



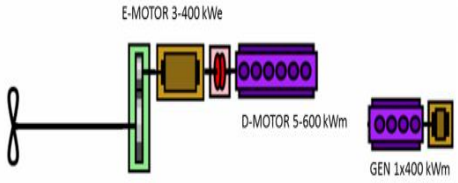
12. ábra: A DE2 hajtásrendszer sémája, A változat



13. ábra: A DE2 hajtásrendszer sémája, B változat



14. ábra: A HIBRID hajtásrendszer sémája, A változat

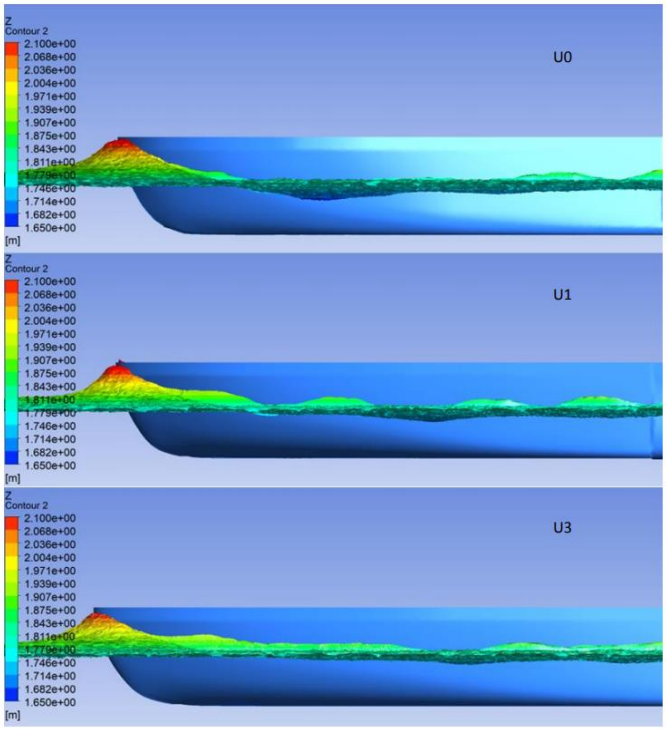


15. ábra: A HIBRID hajtásrendszer sémája, B változat

3. Optimizing electric system

	MS ELSAVA	MS ULM	MS JOHANNA	MS MELANIE-H
calculated yearly electric consumption now	**34 485**	**32 958**	**63 230**	**15 984**
development of engine type eletric usage	13%	25%	3%	22%
development of lighting system	‹1%	‹1%	‹1%	‹1%
development of heating, cooling, water supply system	25%	27%	38%	18,7%
estimated yearly consumption after development (KVAh)	**21 380**	**15 813**	**37 308**	**9 749**
decrease of yearly consumption after development %	**62%**	**48%**	**59%**	**61%**
auxiliary engines consumption % of total, now	**19%**	**12%**	**12%**	**12%**

4. MS Ulm hull conversion



Findings on hull conversion:

1. Either cargo carriing capacity decrease or ship should be extended to make better hydrodinamic bow
2. There is no significant difference at draft of 1,8 or 2,3 meters
3. Ideal floating circumstance is at 5m water depth (????)
4. If structure of the ship will be changed, it must be under register company's approval
5. Change of bow might bring 15% decrease in output needs, but it does not mean automatically same spare in fuel

Results:

1. **change of main engines**

   possible reduction in bunker consumption 10-15%, which means similar reduction in quantity of exhaust gases. Old engines producing similar percentage of Carbon gases as the new ones!

2. **hybrid ship, diesel-electric ship,**

   very expensive idea for reconstructing an old ship, only in case of hybrid ship might find some advantage, when passing habited area, accu stored electricity enough for abt 1 hour slow steaming/manouvering, any layout is too large for MS Johanna's engine room, no spare in bunker (even +), only if batteries charged from other source

3. **greening of auxiliary power generation with solar panels and developing performance optimized electric system with phase correction devices**,

   can reduce total consumption of a vessel with upto 7%, low investment cost, fast return on investment.

4. **Hull conversion,**

   reduction in fuel consumption to be found out percentage (but not 15%)

1. Installation of solar panels concept (MS Melanie-H)

- **Investment cost: 200 322,22 EUR +VAT**
- **GBER Article 36:**
  - The aid intensity shall not exceed 40 % of the eligible costs
  - It may be increased by 20 percentage points for aid granted to small undertakings like FLUVIUS
- **Grant amount requested: 118 393,33 EUR**
- **Aid intensity: 59%**
- **Internal financial rate of return: 33%**
- **The implementation of the project does not require additional resources**

2. Hibrid propulsion vessel concept (MS Johanna)

- **Investment cost: 1 319 625,41 EUR +VAT**
- **GBER Article 36:**
  - The aid intensity shall not exceed 40 % of the eligible costs
  - It may be increased by 20 percentage points for aid granted to small undertakings like FLUVIUS
- **Grant amount requested: 352 575,25 EUR**
- **Aid intensity: 27%**
- **Internal financial rate of return: -3%**
- **The implementation of the project does not require additional resources**

3. Hull conversion concept (MS Ulm)

- **Investment cost: 281 000 EUR +VAT**
- **GBER Article 38 Investment aid for energy efficiency measures:**
  - The aid intensity shall not exceed 30 % of the eligible costs
  - It may be increased by 20 percentage points for aid granted to small undertakings like FLUVIUS
- **Grant amount requested: 88 000 EUR**
- **Aid intensity: 31%**
- **The implementation of the project does not require additional resources**

4. Main engine replacement concept (MS Elsava)

- **Investment cost: 732 000 EUR +VAT**
- **GBER Article 36:**
  - The aid intensity shall not exceed 40 % of the eligible costs
  - It may be increased by 20 percentage points for aid granted to small undertakings like FLUVIUS
- **Grant amount requested: 349 200 EUR**
- **Aid intensity: 48%**
- **Internal financial rate of return: 2%**
- **The implementation of the project does not require additional resources**

5. Electrical network renovation concept (MS Johanna)

- **Investment cost: 59 605,41 EUR + VAT**
- **GBER Article 36:**
  - The aid intensity shall not exceed 40 % of the eligible costs
  - It may be increased by 20 percentage points for aid granted to small undertakings like FLUVIUS
- **Grant amount requested: 34 368,66 EUR**
- **Aid intensity: 58%**
- **Internal financial rate of return: 348%**
- **The implementation of the project does not require additional resources**

Lessons learnt by Fluvius:

1) Such a complex, comprehensive environmental survey has not been carried out for the fleet before: Air loads (emissions), water pollution, wastewater generation, Noise and vibration protection, waste management, energy management, material flow, hazardous material use, total emissions - ecological footprint

2) Old engines emission values are not dramatically different from the Stage5 engine (No_x are higher)

3) In 2020 stage5 engines does not exist by their own, exhaust gas treating equipment must be added

4) The price of the exhaust treater system is almost the same (90%) as the price of the main engine

5) Ulm hull design: too expensive investment for uncertain result

6) Installing a phase corrector is a must on all ships

7) Installation of solar panels feasible, technically possible, we would do it on our vessels

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András Kiss

Fluvius Kft
Forgách u. 9/B, 1139 Budapest Hungary
M +3620 934 2689 T +3612371100
fluvius@fluvius.hu
W www.fluvius.hu

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GRENDEL “Green and efficient Danube fleet”

Towards modernisation & greening of Danube inland waterborne sector and strengthening its competitiveness

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